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GREENFIELD EXPLORATION PROSPECTS OF OROGENIC GOLD MINERALIZATION IN AND AROUND LAWA AREA, NORTH SINGHBHUM MOBILE BELT, EASTERN INDIAN CRATON

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ABSTRACT

Palaeo to Meso proterozoic North Singhbhum Mobile Belt (NSMB) refers to an assembly of the multiply folded, low to medium grade meta-sedimentary and meta-igneous rocks of Proterozoic age (1.0–2.4 Ga) lying between the Archaean Singhbhum Craton also known as Archaen Cratonic Core Region (ACCR>2.4 Ga) in the south, and the Meso/Neo-Proterozoic (0.9–1.7 Ga) Chotanagpur Gneissic Complex (CGC) in the north. The NSMB and the CGC are separated by the Tamar–Porapahar–Khatra–Fault (TPKF), also referred to as the Northern Shear Zone (NSZ). Further to the south, the NSMB and the Singhbhum Craton is separated by the Copper Belt Thrust (CBT), referred as the Shinghbhum Shear Zone (SSZ). In the northern part of the NSMB, mica schists fringing the CGC document a northward increase in strain and temperature (greenschist to amphibolite facies).

The geological set up of the North Singhbhum mobile belt bears a close resemblance to the other major gold producing orogenic metamorphic/mobile belts. North Singhbhum Mobile Belt indicates a complex history of sedimentation, magmatism, deformation and metamorphism. The recent finding of important gold prospects within the NSMB has generated a huge debate over the exploration policy, which needs to be revived to achieve considerable targets in terms of the finding of new gold deposits. The NSMB holds all the critical fundamental controls on regional scale which are very important for the formation of gold deposits. The presence of crustal scale shear zone in any orogenic mobile belt has a primary control on the gold enrichment process as it provides the conduit for the progressive/repetitive transfer of gold from the deeper part to all the important shallow level seismogenic regime (Brittle ductile regime). North Singhbhum Mobile belt holds all the other regional scale controls in terms of lithology, structure, metamorphism and tectonic setting, suitable for the exploration of gold mineralization.

KEYWORDS: Gold Mineralization, NSMB, Archean, Craton, Singhbhum Shear Zone

INTRODUCTION

The Eastern Indian shield (EIS) comprises of Archaean Singhbhum Cratonic nucleus made up of different phases of Singhbhum Granite (SG), North Singhbhum Mobile belt (NSMB), consisting of volcano–sedimentary sequence with Dalma Volcanic Belt (DVB) emplaced along its spine and the Northern high grade mobile belt of Chhotanagpur Granite Gneissic Complex (CGGC).

The NSMB encompassing the Dhanjori, Chaibasa and Dalma Volcanic Belt rest on Singhbum Granite basement. The NSMB near its southern periphery is marked by the famous Singhbhum Shear Zone (SSZ) characterized by intense ductile shearing/thrust with rich Copper- Uranium and Gold as by product. This NSMB greenschist facies package comprising of meta-sedimentaries, felsic volcanics, mafic/ulatramafic, granitoids and alkaline/carbonatite suite of rocks is bounded by the CGGC attaining amphibolite to granulite facies in the north. Work carried out by Geological Survey of

India (GSI) during last three decades established belt-wise gold mineralization in the EIS in the Archaean Kunderkocha –Gorumahisani greenstone belt, Jharkhand, Archaean to early Proterozoic volcano–sedimentary Iron Ore Group (IOG) around Telkoi in Keonjhar district Orissa to the SW of Singhbhum Craton and in several sectors of NSMB (Figure 1 and 2). Palaeo-Proterozoic Quartz- Pebble Conglomerate (QPC) hosted gold, close to the contact of Singhbhum Granite basement and the byproduct gold associated with copper sulphide ores in SSZ are also important finding by GSI in recent times. Gold associated as byproduct of gold with Cu-U mineralization along SSZ and Palaeo- Proterozoic gold in QPC's in the gap areas of Dhanjori Basin overlying the Singhbhum Granite should also be searched for Gold.

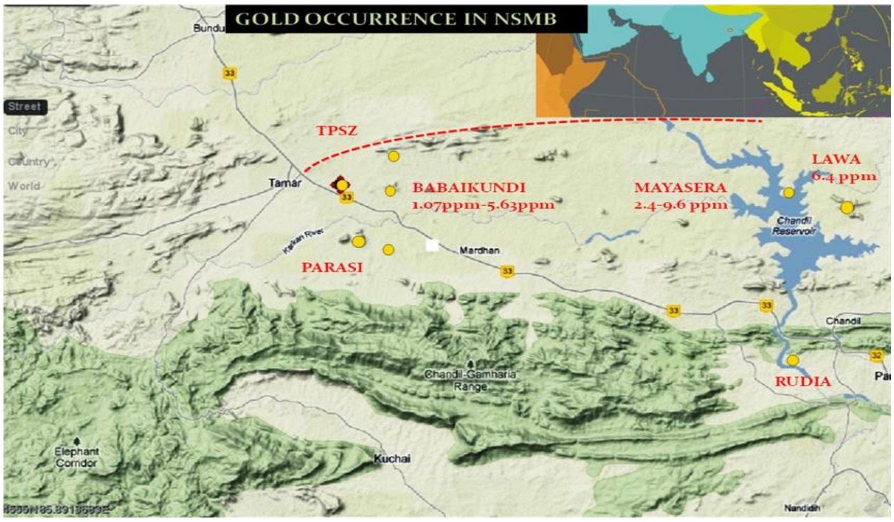

Figure 1: Gold Occurrences in NSMB, Jharkhand

([http://wikimapia.org/#lang=en&lat=33.804256&lon=74.257965&z=10&m=b&search gold occurrences](http://wikimapia.org/#lang=en&lat=33.804256&lon=74.257965&z=10&m=b&search) Jharkhand)

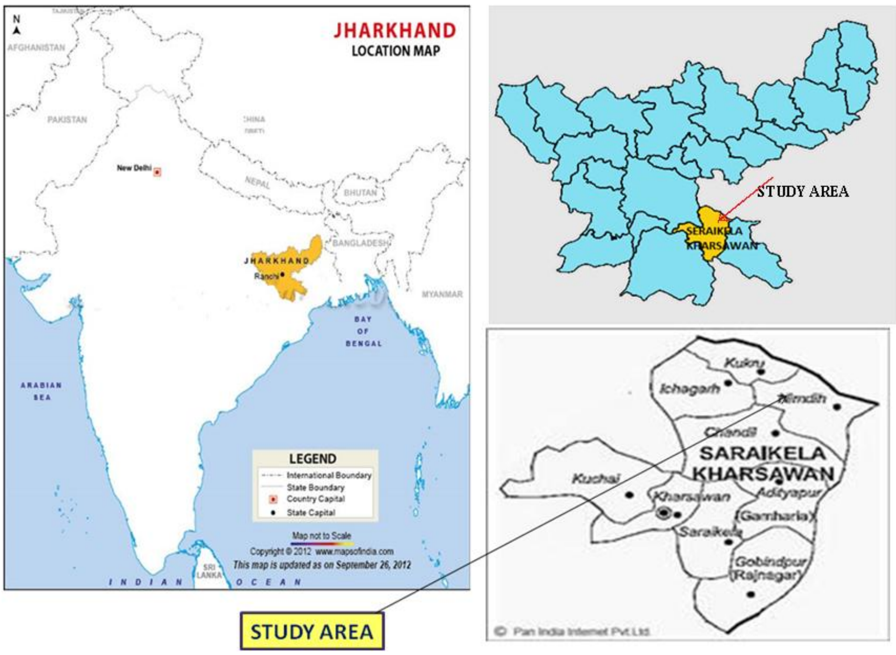

Figure 2: Location of Study Area in Jharkhand & India Political Map

Location and Accessibility

The study area is situated north west of Lawa village in the Nimdih Block of Seraikella-Kharsawan district, Jharkhand and the locality is included in the Survey of India Topo Sheet No. 73 I/4 (Figure 2). Lawa is situated at a distance of about 50 km. due N25°W of Jamshedpur. The nearest Railway Station is Nimidih (S.E.Rly,) which is about

45 km. from Tatanagar on the Tata-Asansol line. The deposit is connected by a six kilometer fair weather road with the National Highway near Raghunathpur situated at a distance of 46 km. from Tatanagar.

Regional Geology

The Singhbhum crustal province consisting of south eastern part of Jharkhand and north of Orissa, occupies an area of approximately 50,000 km^2. The Singhbhum crustal province can be recognized in two distinct provinces. The northern younger, Singhbhum Group (Sarkar and Saha,1962), also known as North Singhbhum Fold Belt (NSFB) (Gupta and Basu, 2000) or North Singhbhum Mobile Belt (NSMB) (Bhattacharya and Mahapatra, 2008) or Singhbhum Mobile belt (SMB) (Misra, 2006), and the southern older, Iron Ore Series, or Iron Ore Group (IOG) province (Sarkar and Saha, 1962), also known as Archean granite–greenstone terrain or Singhbhum Granite Craton (Acharyya et al., 2008; Sengupta et al., 1997 and Mukhopadhyay, 2001.)

The general geological framework of the Jharkhand-North Orissa Precambrian terrain, often called as Singhbhum-Orissa Craton was established through the works of Dunn and Dey (1942) which has been bounded on both the sides by mobile belts. The Singhbhum-Orissa Iron Ore Craton (SOIOC) is the oldest Archean nucleus of eastern India out of which major part is occupied by Singhbhum Granitic Batholithic Complex (SGBC). This north Singhbhum mobile belt registered a complex interplay of tectonism and sedimentation (Bhattacharya and Mahapatra, 2008). The boundary between the Singhbhum Mobile Belt (SMB) supracrustals and Singhbhum-Orissa Craton is demarked by the Singhbhum Shear Zone (SSZ) (Figure 6). This shear zone shows multiple reactivations, the oldest one at ~3.09 Ga, followed by subsequent reactivation during Paleo and Mesoproterozoic periods (Misra and Johnson, 2005). The shear zone trend eastward from Parahat in western Singhbhum to the Chakradharpur and then it takes a southward swing in the close to Jamshedpur. The early works envisaged a complex stratigraphic set up within the belt comprising of metamorphosed calc alkaline suite of rocks (OMTG) and is overlained by supracrustal sequence known as the Iron Ore Group in which majority of Indian iron ores occur in addition to the mafic/ultramafic rocks as the Dalma lava, is younger than Iron Ore Group (Dunn and Dey, 1942.)

The central oval shaped Archean nucleus of this province is known as Singhbhum-Orissa-Iron-Ore-Craton (SOIOC) (Saha, 1994) or Singhbhum Orissa Craton (SOC) (Misra, 2006) (Figure 6). These two provinces are separated by a sheared zone, known as Singhbhum Shear Zone (SSZ); extending over a strike length of more than 160 km (Mukhopadhayay et al., 1975; Mukhopadhayay, 2001; Saha, 1994; Sengupta, et al., 2000 and Mukhopadhayay, 2001). This shear zone marks the northern boundary of this nucleus while the Sukinda thrust and the Gondwana boundary fault of the Talchir coal field form the southern boundary. The supracrustal rocks of the region were earlier thought to belong to one sequence, and were grouped within two divisions by Sarkar and Saha (1962), the Iron Ore Group of the older province and the Singhbhum Group of the younger province, the Singhbhum Granite being intrusive in to the former and forming the basement.

The Precambrian crust of eastern India grew by accretion of younger terrain around this nucleus. The Singhbhum Shear Zone marks the northern boundary of the Archean nucleus on the eastern side (Figure 6). On the western side the northern boundary is not well defined. The younger Sukinda thrust and the Gondwana boundary fault of the Talchir Coalfield form the southernmost boundary. The Singhbhum Granite batholithic complexes occupy the major part of this region, which occupies a north- south elongated track of about 10,000 sq. km. The Iron Ore Group (IOG) rocks occur in basins which are peripheral to the Singhbhum Granite massif or are present as thin septa within the granites. These have, at times, been referred to as greenstone belts (Acharya, 1993).

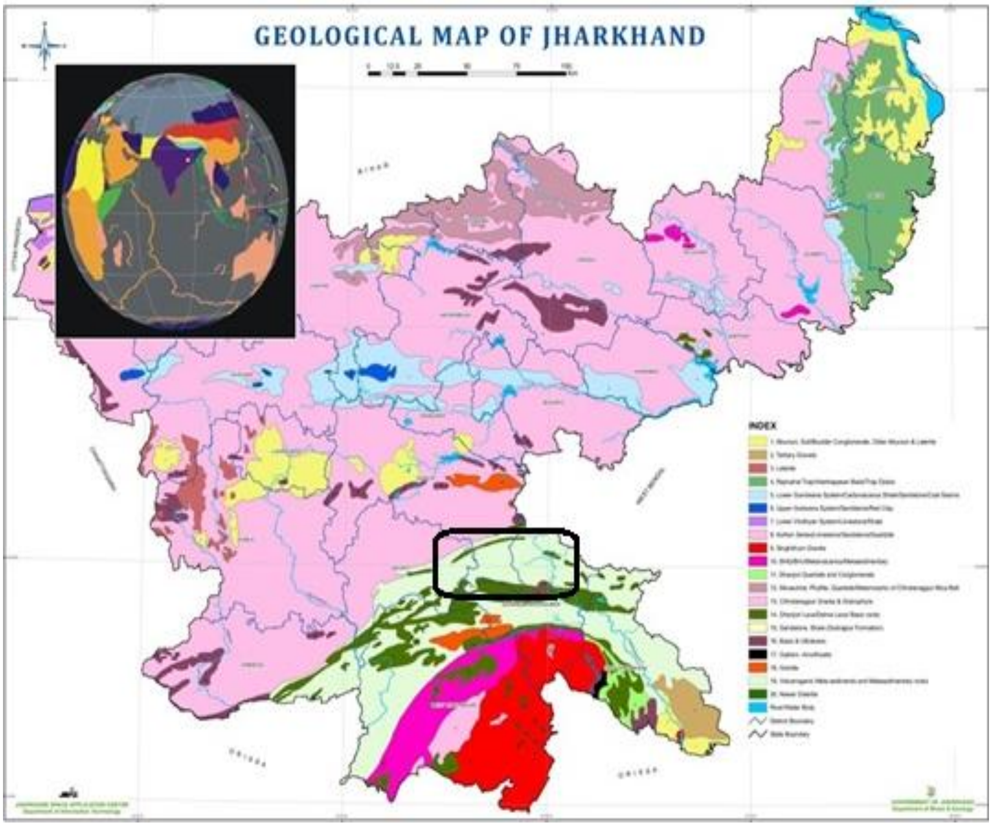

Figure 3: Generalised Geological Map of Jharkhand (Department of Mines & Geology, Government of Jharkhand)

North Singhbhum Mobile Belt

The North Singhbhum Mobile Belt (NSMB) is a 200 km long E-W trending linear fold belt sandwiched between the SGC in the south and CGC in the north (Figure 6). The NSMB supracrustals overlie the Singhbhum granite basement and its equivalents with an erosional unconformity.

The NSMB is divided into two parts by the DalmaVolcanic Belt. The portion of the supracrustal belt between the Singhbhum Shear Zone and the Dalma volcanics was defined as the Singhbhum Group (Saha, 1994). However, there appers to be some confusion on the status of supracrustals lying between the Dalma volcanics and the Chotanagpur Gneissic Complex. Dunn and Dey (1942) and Sarkar and Saha (1962) believed that the northern supracrustals are the continuation of those south of the Dalma volcanics. Sarkar (1988) considered the Dalma volcanics as a suture zone and the supracrustals to the north and south of this volcanic belt belong to different provenances. However, after reviewing all the geological and geophysical data, Saha (1994), suggested that the Dalma Volcanic Belt represents an intracratonic rift zone where the supracrustals on either side of this belt were deposited in a continuous marine basin and belong to the Singhbhum Group. Ray et al. (1996) suggested that the litho-package north of Dalma Range and south of CGGC distinctive is the presence of large volumes of vitric, lithic or crystal lithic tuffs occurring inter-bedded with basic and ultrabasic rocks that do not show relict flow structure.

The multiply deformed and metamorphosed tectonites of NSMB represent a thick volcano-sedimentary pile indicating multibasinal deposition and volcanism in partially homotaxial elongate sub-basins, now representing a thrust-fold belt (Gupta, 2010). The peak metamorphism in the rocks of NSMB is dated at 1.6 Ga. Two major volcanic foci have been recognized in the belt, (i) along the cratonic margin (Dhanjori: 2.4- 2.1 Ga, Ongarbira: 2.35 Ga, Simlipal volcanics), and (ii) along the spine of the belt (Dalma volcanics: 2.3-2.0 Ga) (dates from Saha, 1994; Roy et al., 2002; Acharyya et al., 2008).

Geology of the Lawa Area

The country rocks may be broadly divided into three major types: phyllites, quartzites and mica schists. The valley to the south comprises of phyllite which extends to the north up to the foot hill region. The quartzites are mainly exposed in the southern and the northern ridges running parallel to each other, while mica schist occupies the valley between them (Figure 4). Phyllites occur to the south of the mineralized hills (Bhaluk Khad-Tamapahar) and mica schists to the north, although intercalated bands of phyllite as well as mica schist are often found with the main quartzite body. These intercalations are of very limited extent. The rocks of the area are intruded by quartz veins of different dimensions and dispositions. Quartz veins are most extensive in the quartzites and these belong to more than one generation. In addition to those, some exposures of ferruginous quartzite rock are found in the area, the most prominent of these exposures are situated towards east of the southern foot hill. Sericite quartz schist, sericite quartzite, sheeted quartzite etc. within the main quartzite body, mark the zone of shearing. Intense shearing has also produced mylonitized complexes which are best seen in the underground workings (Mukherjee et al., 1969). In general, it can be said that different lithologic units have been formed in this area by regional metamorphism of argillaceous sediments intercalated with arenaceous layers and which were intruded by basic sills and quartz veins through various stages.

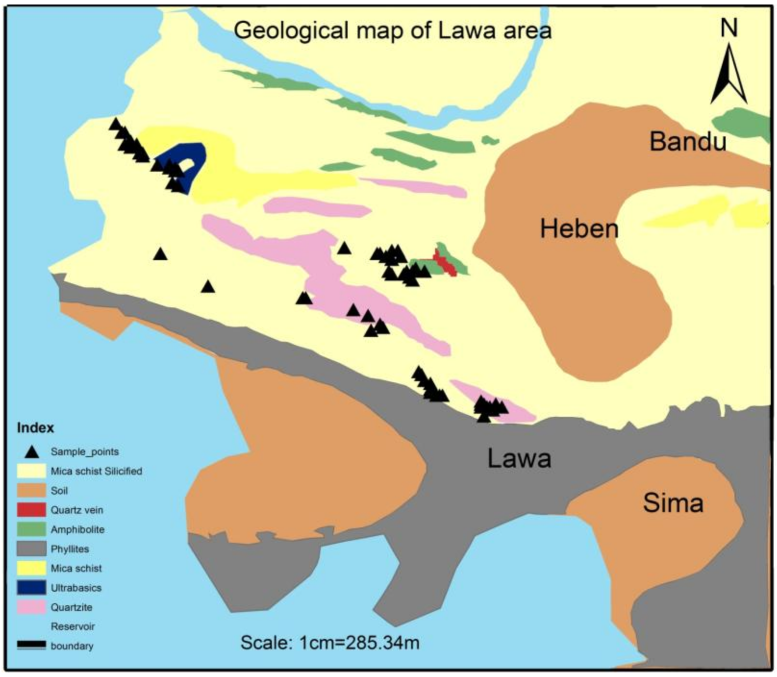

Figure 4: Geological Map of Lawa Area (Modified after Banerjee and Banerjee, 1966)

Gold Occurrences in and around the Area

Three old workings are present at Lawa, located at ridge tops and having strike adit entrances (Figure 5). The Bhalukkhad ore body has been worked from two sides in the East and West mines by separate adit entrance and two levels developed over a total strike length of 80 m upto a depth of about 30 m. These two old workings are not connected, (Gupta 1975, 1986). At the western part of the deposit Tamapahar working covers a similar strike length with one adit entrance and two levels. Underground channel samples drawn from the adit levels (Arogyaswami and Dutta, 1948) of Bhalukkhad workings obtained auriferous bodies with 11 .85 g/t Au over 22.5 m length and 2.44 m width in the eastern mine and 11 .08 g/t Au over 37.95 m length and 1.76 m width in the western mine. According to Arogyaswamy and Dutta (1948) the auriferous quartz comprising the ore shoots is found in the old workings at Lawa along the axis of the drag folds within the meta-sedimentary rocks in a more or less en-echelon fashion.

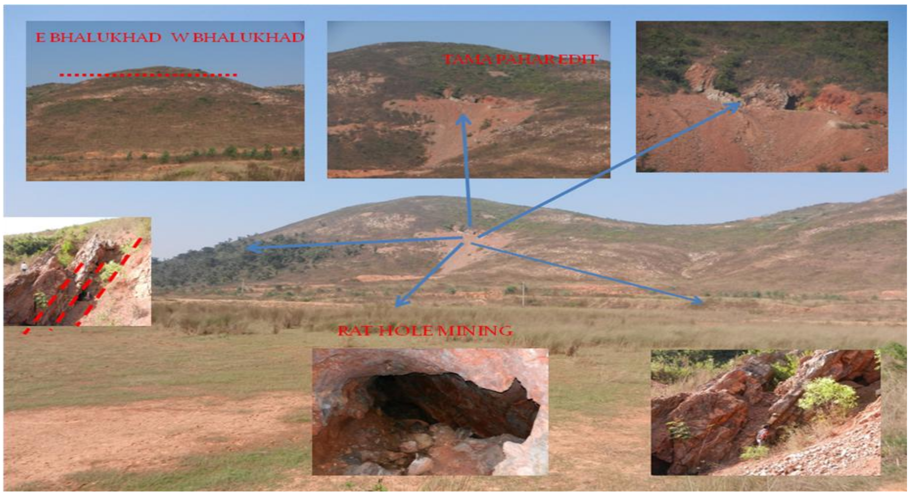

Figure 5: Rat Hole Mining in Lawa Mayasera Area

Some of the most prominent gold occurrences of the North Singhbhum Mobile Belt are present in the metasedimentary belt lying in north of Dalma volcanics (Figure 6). These occurrences are marked from east to west at Lawa, Maysera, Ichhagarh, Nawadih, Babaikundi and Parasi (Figure 6). Many earlier workers (Dunn, 1929; Dunn and Dey, 1942; Sarkar and Saha, 1962, Saha, 1994) considered the metasediment dominated sequence to the north of the Dalma Volcanics be an equivalent of Chaibasa rocks present to the south of the region, marks a structural repetition across the intervening 'Dalma syncline'.

It is now widely recognized that the northern metasedimentary belt differs from southern pile in having prominent black shale-chert-rhythmite, tuffaceous sediments and impure limestone / dolostone (along southern margin) with large mafic-ultramafic intrusives, acid volcanics (Rb-Sr age: 1.45-1.5 Ga - Sengupta et al., 2000; Shrimp U-Pb zircon date: 1.63 Ga - Nelson et al., 2007), syenite, nepheline-syenite and carbonatite (along northern margin). The sedimentary assemblage of this area represents deeper water facies compared to Chaibasa-Dhalbhum sediments and has profuse acid-intermediate ignimbrite (Acharyya et al., 2006). This sequence has been named as "Chandil Formation" by some recent workers. In this formation the metamorphic grade ranges from greenschist to greenschist-amphibolite transition facies in west, to high amphibolite- anatectic assemblage (around S type Kuilapal Granite) in east.

The evidences of extensive mining activity all along the central shear zone, and all available old records testify the occurrence of workable gold in the quartz veins of the shear zone. From the nature of gold workings it becomes quite evident that the most persistent tabular quartz vein which dips to the north was of main economic interest for the old miners. Though the remaining scanty exposures of this vein do not give high value for gold. High values for gold have been obtained from the quartz vein pieces lying in the dumps (Lahiri, Gupta & Chakravorty, 1974).

The auriferous quartz veins of this area are mostly milky white in colour grading into light grey type. The samples were examined under the ore microscope and were found to contain chalcopyrite, pyrite, pyrrohotite, covellite & sphalerite in borehole cores, minor amounts of pyrite and chalcopyrite have been noted in the quartz veins and the surrounding host rock. The disposition and nature of the main auriferous vein indicate that the emplacement took place along a shear plane (which might be a originally joint plane). The shear planes are found to be roughly parallel to, the S3 planes prevalent in the metapelites. As a result, the quartz vein has assumed a discordant relationship with respect to the most prominent planar feature i.e. the regional schistosity (S2). No crushing is evidenced in the quartz vein. Similar warps are also displayed by the shear planes and S3 planes in the region. This suggests that the emplacement was late tectonic with respect to shear movements.

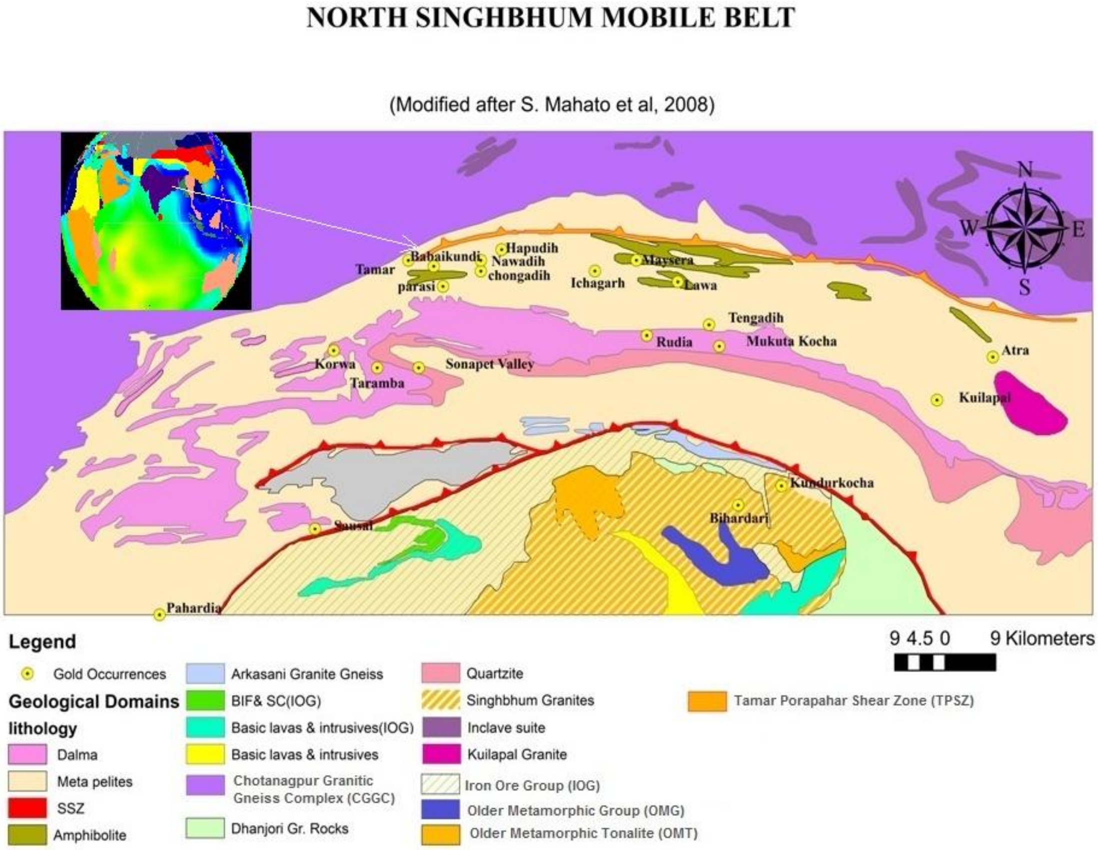

Figure 6: Geological Map of NSMB Showing the Gold Occurrences (Modified after S. Mahato & et al, 2008)

CONCLUSIONS

- The gold mineralization at Lawa appears to be dominantly structure controlled although it has some specific association with particular rocks such as meta-volcano sedimentary sequences. The old workings follows the shear zones where intense crushing and intrusions of auriferous quartz veins has taken place. The zone of shearing is not a continuous feature but comprises a number of detached shear planes of limited extent along strike.
- The rocks in the area represent a metamorphic tectonite, displaying a regional fold with superimposed folding and shearing effects. The two parallel quartzite bands dipping in opposite direction, exposed in the southern and northern ridges, appear to represent the complementary limbs of a single asymmetric antiform plunging towards WNW having mica schist in the core.
- Petrographic studies revealed presence of minerals like pyrrhotite, pyrite, chalcopyrite, arsenopyrite, sphalerite, covellite along with gold. On the basis of mineralogical, textural association and deformational parameters a three stage paragenetic order is proposed for the Lawa area. These studies support a second and third stage occurrence of gold in the area.
- Overall, the area seems favorable for gold mineralization and detailed studies involving chemical analysis of rocks, geochemical sampling and drilling should be conducted in order to establish the economic aspect of the deposit and to delineate the boundaries of the ore bodies.

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